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Anterior Approach to Dorsal Short Hepatic and Right Hepatic Veins in a Right Hepatic Lobectomy

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Summary

A simple procedure of right hepatic lobectomy for bulky liver tumors is proposed. The procedure is named "Anterior approach", which is characterized by transection of hepatic parenchyma without mobilization and rotation of the right hepatic lobe. The transection directly reaches the ventral surface of the retrohepatic inferior vena cava first at the portion of caudate process. The hepatic parenchymal transection proceeds from ventral to dorsal and from caudal to cranial. Several dorsal short hepatic veins are severed on the ventral surface of the IVC and the right hepatic vein is finally severed from inside. This method enables the minimization of operative stress and is especially useful for cases with a huge tumor in the right hepatic lobe which invades the diaphragm or thoraco-abdominal wall.

Introduction

In the standard right hepatic lobectomy, the mobilization and rotation of the right hepatic lobe are performed in order to sever the dorsal short hepatic and right hepatic veins. These procedures enable the dissection of the dorsal short hepatic veins at the peritoneal reflection on the right side of the retrohepatic inferior vena cava (IVC)¹⁾. However, they are usually very difficult in cases with huge liver tumors occupying the entire posterior segment or right hepatic lobe. In addition, it has recently been reported that the rotation of the right hepatic lobe towards the upper left side induces hepatic ischemia and congestion of portal blood flow, resulting in deterioration of the remnant liver function²⁾. In order to overcome these problems, we employ an approach for dissecting the dorsal short hepatic and right hepatic veins in a right hepatic lobectomy. Called the "Anterior approach," it is characterized by a direct approach to the dorsal short hepatic veins and right hepatic vein from the ventral surface of the IVC after splitting the hepatic parenchyma. Since this approach avoids both mobilization and rotation of the right hepatic lobe, it is not only a much safer way to perform a

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Key words: Right hepatic lobectomy, Dorsal short hepatic vein, Right hepatic vein, Liver tumor, Operative stress

resection of a huge right hepatic tumor, but also minimizes intraoperative stress to the remnant liver.

In this article, we introduce detailed operative procedures of the anterior approach in the right hepatic lobectomy, and discuss its indication and intraoperative stress to the remnant liver.

Operative procedures of the anterior approach

The principal procedures of the anterior approach are summarized in Table 1. The hepatic hilus is dissected in a standard fashion. The right hepatic artery and right branch of the portal vein are severed, and several right branches to the caudate lobe are also severed. The line of hepatic parenchymal transection is marked with an electric cautery about 1 cm to the right side along the demarcated Cantlie line. The bare area and the suprahepatic IVC are dissected as widely as possible prior to transection of the hepatic parenchyma. The infrahepatic IVC is also exposed until the caudate process of the liver becomes free from the IVC, by which the first dorsal short hepatic vein can be recognized. The caudate process is then partially transected longitudinally to decide a line of the transection ventral to the retrohepatic IVC.

In order to hold the transected liver tissues and pull them apart laterally, two rows of mass-ligations are placed along both sides of the transection line at the inferior edge of the liver. The hepatic parenchymal transection is then started from ventral towards dorsal, and from caudal towards cranial using an ultrasonic scalpel, CUSA (Fig. 1-A). Bleeding from small glissonian branches is simultaneously controlled by a bipolar electric coagulator. On the way, as the transected face reaches the ventral surface of the retrohepatic IVC, large vessels, including the peripheral main branch of the middle hepatic vein, are carefully severed and suture closed. The transection of hepatic parenchyma should be continued step by step, always from ventral towards dorsal, and from caudal towards cranial sides (Fig. 1-B). In the meantime, both the right and left lobes are pulled by the two holding strings so as to split them, clearly exposing the dorsal short hepatic veins on the ventral surface of the retrohepatic IVC. Every time a dorsal short hepatic vein is exposed on the surface of the IVC, it is carefully dissected, ligated and severed from the IVC. When the vein is relatively large, it should be clamped and severed, and suture closed. There are several dorsal short hepatic veins before the transection reaches the suprahepatic IVC. The peritoneal reflection on the right side along the IVC

Table 1 Principal procedures of right hepatic lobectomy through anterior approach

1. Dissection of the bare area and around the suprahepatic IVC
2. Cholecystectomy, dissection of hepatic hilus, severance of right hepatic artery, portal vein and caudate branches
3. Dissection of the hepato-renal ligament
4. Dissection of the infrahepatic IVC
5. Incision at the midline of the caudate process
6. Transection of hepatic parenchyma from inferior edge of the liver toward dorsal
7. Transection reaches the incised portion of caudate process
8. Dissection of ventral surface of the retrohepatic IVC from caudal toward cranial
9. Severance of the dorsal short hepatic veins and peritoneal reflection between the retrohepatic IVC and the liver
10. Complete exposure of the retrohepatic IVC
11. Dissection of the right hepatic vein and its severance
12. Severance of IVC-ligament dorsal of the right hepatic vein
13. Additional resection of diaphragm with tumor invasion (if necessary)

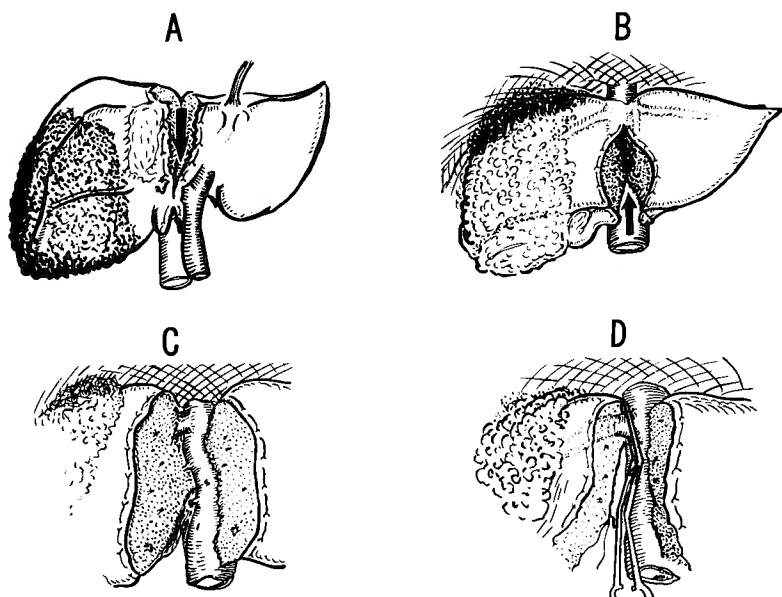


Fig. 1 The principal procedures of the right hepatic lobectomy with an anterior approach.

- A: Initial transection of the hepatic parenchyma from inferior edge of the liver towards the caudate process.
 B: Transection of hepatic parenchyma proceeds from caudal towards cranial side along the ventral surface of the retrohepatic IVC.
 C: Complete exposure of the retrohepatic IVC and the right hepatic vein.
 D: Clamp of the right hepatic vein from inside.

Table 2 Indication of the anterior approach

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|--|
| 1. Cases with huge malignant liver tumors occupying the entire posterior segment or right hepatic lobe |
| 2. Cases with tumor invasion into the diaphragm or thoraco-abdominal wall |
| 3. Cases suspected of tumor invasion into the retrohepatic IVC from the right side |
| 4. Cases with compromised hepatic functional capacity due to chronic liver damage |

can be severed after this. There are rough connective tissues around the IVC where the right hepatic vein joins. When these connective tissues are carefully dissected, the right hepatic vein is completely exposed (Fig. 1-C). There are also several dorsal short hepatic veins on the right side of the retrohepatic IVC. These veins are carefully severed from the IVC. When all of the dorsal short hepatic veins are severed, both the right and remnant left lobe can be spread widely, and the right hepatic vein is now easily clamped from the side of transected parenchymal face before being severed (Fig. 1-D). The stump of the vein is closed by running-suture. After the IVC-ligament located dorsal to the right hepatic vein is severed, the right hepatic lobectomy is completed. When tumors invade the diaphragm and thoraco-abdominal wall, we perform an additional resection of these parts thereafter.

Indications of the anterior approach

Indications of the anterior approach are summarized in Table 2. Since the anterior approach does not need any mobilization and rotation of the right hepatic lobe, a case with huge liver tumors

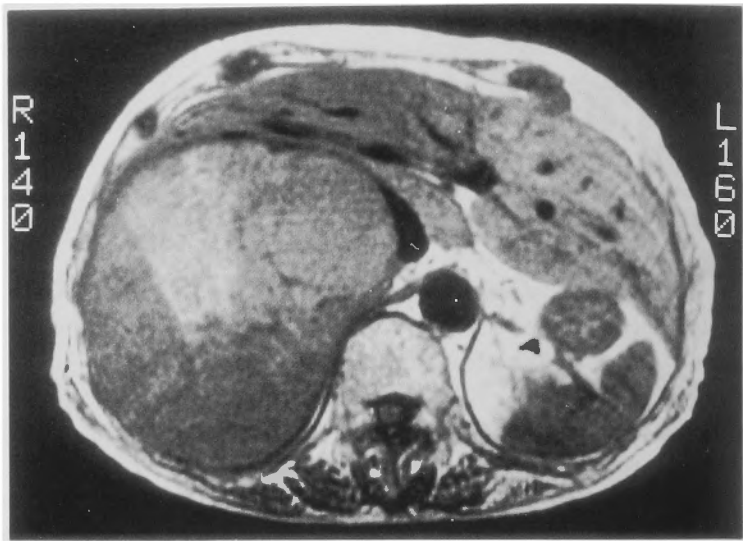


Fig. 2-A MRI (magnetic resonance imaging) of a 76 year-old female with a huge hepatocellular carcinoma occupying the entire posterior segment. The tumor is strongly compressing the right hepatic vein towards ventral side, and the anterior segment is thin due to the compression.



Fig. 2-B MRI (magnetic resonance imaging) of a 76 year-old female with a huge hepatocellular carcinoma occupying the entire posterior segment. The tumor compresses the retrohepatic IVC towards left side, and the IVC exhibits narrowing.

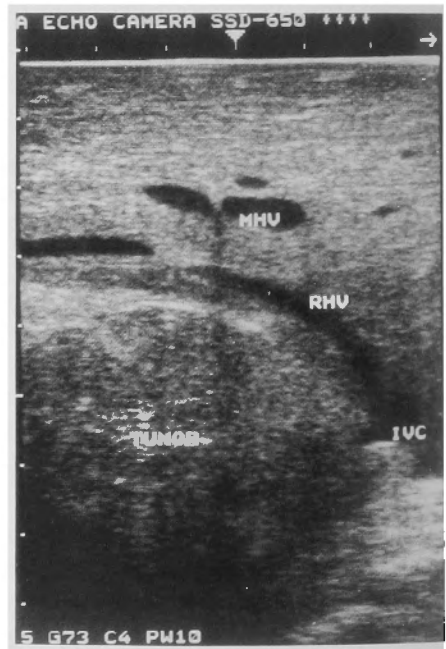


Fig. 2-C US (ultrasonography) image of a 76 year-old female with a huge hepatocellular carcinoma occupying the entire posterior segment. The tumor compresses both the right hepatic vein and the IVC at the confluence. RHV: right hepatic vein, MHV: middle hepatic vein, IVC: inferior vena cava.

occupying the posterior segment or an entire part of the right lobe becomes a good indication for this approach (Fig. 2-A, B, C). It is technically very hard and can even be dangerous to employ the standard method to dissect dorsal short hepatic and the right hepatic veins extrahepatically from the right side for cases with huge tumors in the right hepatic lobe. The second indication is an occasion

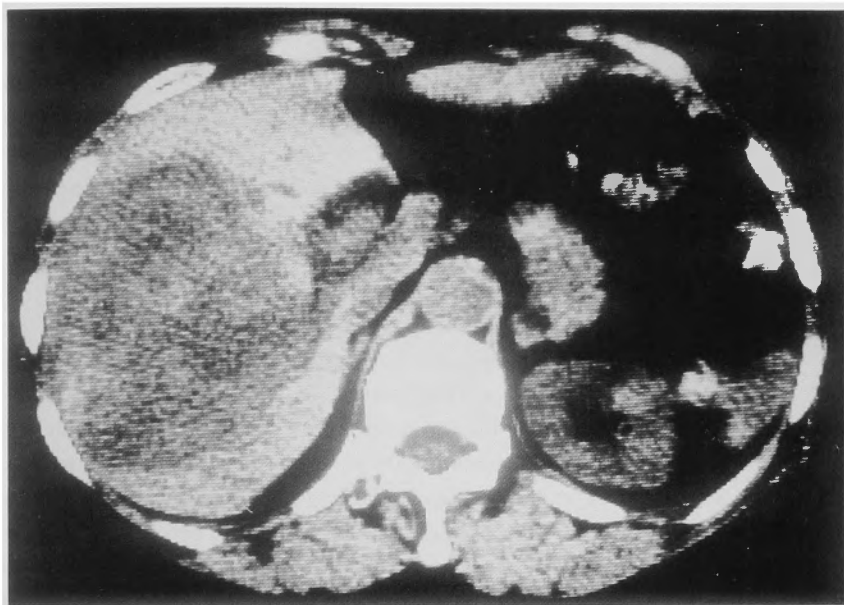


Fig. 3-A CT (computed tomography) of a 75 year-old female with a cholangio-cellular carcinoma. The tumor occupies the entire part of the right lobe.



Fig. 3-B CT (computed tomography) of a 75 year-old female with a cholangio-cellular carcinoma. The tumor invades the diaphragm, thoraco-abdominal wall and the right 10th rib.

in which tumors directly invade the diaphragm or thoraco-abdominal wall as shown in Fig. 3-A and 3-B. When the tumor infiltration is very severe, right ribs are also involved in the invasion. In such cases, the anterior approach provides an easier way to reach the retrohepatic IVC than the standard method. The third indication of this approach is in a case suspected of tumor invasion into the retrohepatic IVC from the right side in which a combined resection of the IVC is needed for the curative resection. Anterior resection enables to exploration of the portion of tumor infiltration directly by a wide exposure of ventral surface of the retrohepatic IVC. For the fourth indication, we employ the anterior approach for cases with hepatic functional risk to such a major resection because of chronic liver damages. A rotation maneuver of the right hepatic lobe toward the upper left side is known to be very harmful, inducing a blood congestion in the remnant liver, while the anterior approach avoids that.

Operative stress in the anterior resection

From our experience, operation time needed for the right hepatic lobectomy with an anterior approach ranged widely from 4.5 to 11.2 hours (Data are not shown). It can not be simply compared with that of the standard method, since the local findings as to tumor factors vary widely. The time required for the hepatic parenchymal transection itself was less than 2 hours if tumors did not invade the IVC. In our experiences, intra-operative blood loss ranged from 1200 to 6210 ml in the anterior approach. In the easiest case, it was approximately 400 ml during the procedures of the hepatic parenchymal transection. Generally speaking, we need a little more operation time and intra-operative blood transfusion in the anterior approach than those in the standard method, although they are of course within acceptable ranges. It has been demonstrated that intraoperative AKBR levels in

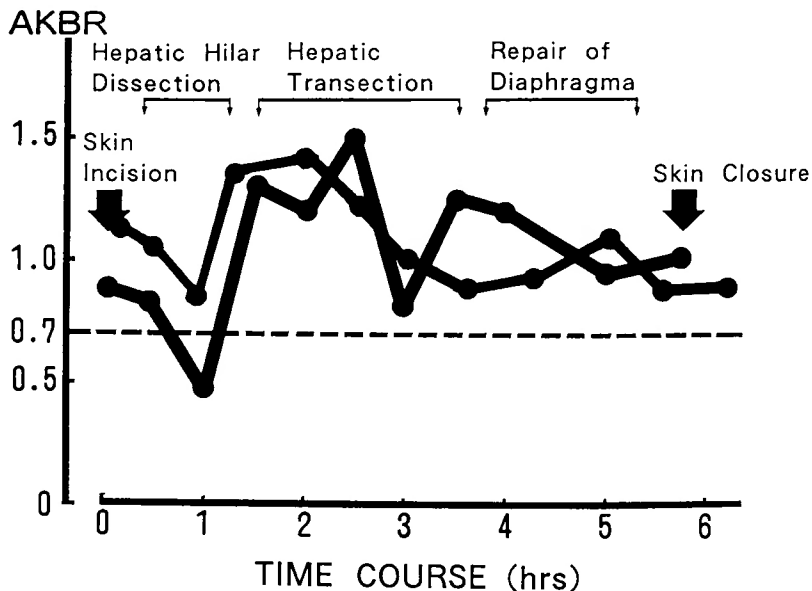


Fig. 4-A Changes in the AKBR levels during the right hepatic lobectomy through the anterior approach for cases with tumor invasion into the diaphragm. The AKBRs are maintained mostly at over 0.7 during the operation.

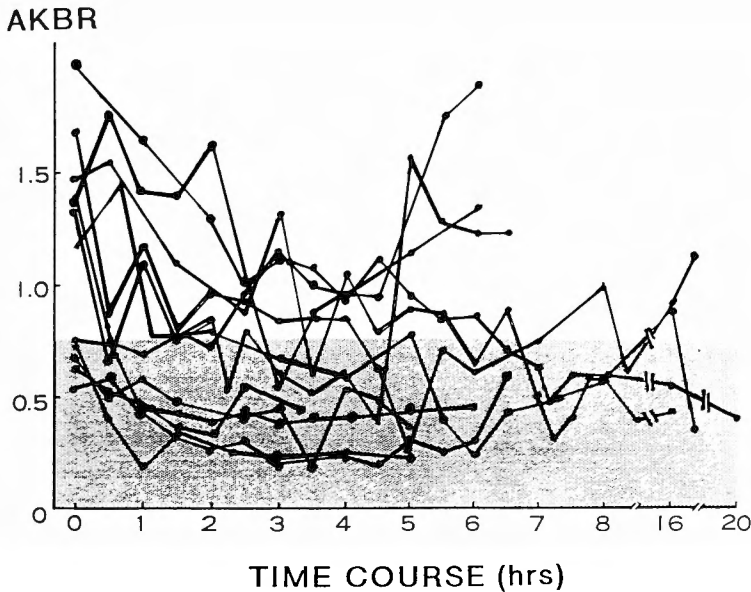


Fig. 4-B Changes in the AKBR levels during the right hepatic lobectomy through the standard methods. The AKBRs frequently decreased to below 0.7 during the operation.

the anterior approach are maintained at high levels of above 0.7 throughout the procedure of the hepatic parenchymal transection, while in the standard method, they often decrease to near critical levels of 0.4. (Fig. 4-A, B).

Discussion

In the standard right hepatic lobectomy procedure, the mobilization and rotation of the right hepatic lobe from right to left are performed in order to expose the retrohepatic IVC prior to transection of the hepatic parenchyma. They are considered to be prerequisites in dissecting the dorsal short hepatic veins that drain from the posterior segment into the retrohepatic IVC¹⁾. This procedure also enables the resection of the right hepatic vein extrahepatically at the level of the suprahepatic IVC. However, in the case of a huge tumor in the right lobe, especially in the posterior segment, the procedure to expose the IVC from the right side is not only technically very difficult but can also be dangerous. This is due to the fact that the procedure causes a strong traction force, with remarkably wide deviation, as the right lobe is rotated towards the upper left side. Moreover, it is almost impossible to perform this procedure when the tumor invades the diaphragm or the thoraco-abdominal wall. The anterior approach for the right hepatic lobectomy or extended right hepatic lobectomy is intended to resolve the problems mentioned above. The approach is to transect the hepatic parenchyma directly from ventral to dorsal and from caudal to cranial, after reaching the ventral surface of the retrohepatic IVC, without mobilizing and rotating the right hepatic lobe. The important and novel point of this procedure is the dissection of dorsal short hepatic veins on the ventral surface of the retrohepatic IVC, and not from the right side of the IVC as performed in the standard method. The final step of this procedure is to dissect and sever the right hepatic vein. If the tumor invades the diaphragm or thoraco-abdominal wall, then the combined resection can be performed after the com-

pletion of the hepatic resection.

The concept behind this procedure was first introduced by STARZL et al. in performing the right trisegmentectomy for huge liver tumors³⁾. They reported that this technique was particularly useful for bulky superior and posterior liver tumors, including those that invaded the diaphragm. This approach seems quite reasonable for the right trisegmentectomy, since the cut surface area of the divided hepatic parenchyma between the left lateral and medial segments is not large. Hence, one can quickly reach the ventral surface of the retrohepatic IVC, and can easily dissect the dorsal short hepatic veins, the middle hepatic vein and the right hepatic vein from inside.

The cut surface area of the liver following a right hepatic lobectomy, the interplane between the right and left lobes, is much larger; nevertheless, we could also enjoy the same technical benefits in this approach. It has been subsequently shown to be appropriate, especially for combined resection of the diaphragm with tumor infiltration, as STARZL et al. had reported in the trisegmentectomy procedure. Furthermore, we can easily determine whether the combined resection of the retrohepatic IVC suspected of tumor infiltration is indicated, since its ventral surface can be easily exposed by splitting the liver parenchyma. If tumor infiltration to the IVC is confirmed, one could perform a combined resection of the IVC without much difficulty by applying a total hepatic vascular exclusion technique, using a centripetal pump for active veno-venous bypass⁴⁾.

In addition to these technical advantages, there is the further advantage of preserving intraoperative liver function. We have demonstrated that rotation of the hepatic lobe is one of the factors impairing remnant liver function during the operation, since this procedure induces hepatic and portal congestion by compressing the middle and left hepatic veins. This has been demonstrated by serial measurements of the intraoperative arterial ketone body ratio (AKBR), which reflects hepatic mitochondrial redox potential⁵⁾. The AKBR can be decreased to below or near the critical level of 0.4 (normal > 1.0) by several intraoperative maneuvers, such as the vascular clamp, mobilization and rotation of the hepatic lobes and the indiscriminate preparation of the hepatic hilus⁵⁾. It has also been shown that the incidence of postoperative complications and organ failure increases as the duration of a depressed intra-operative AKBR is prolonged⁶⁾. Therefore, when the liver has decreased functional capacity due to chronic hepatitis or cirrhosis, it is recommended that potentially harmful intraoperative maneuvers should be avoided or minimized as much as possible in order to preserve the functional capacity of the remnant liver. A recent study has shown that the AKBR can be maintained at high levels during the operation and the subsequent early postoperative period, even in cases of cirrhosis and chronic hepatitis, in which the AKBR generally decreases to below 0.7 of the near critical level during major hepatic resection^{7,8)}. From our experience, patients tolerated the operation well in spite of poor conditions both in tumor factors and hepatic function, suggesting that this procedure helped a great deal to minimize operative stress for patients.

In conclusion, the right hepatic lobectomy performed through an anterior approach is particularly useful for 1) cases with huge malignant liver tumors occupying the entire posterior segment or right hepatic lobe, 2) cases with tumor invasion into the diaphragm or thoraco-abdominal wall, 3) cases of suspected tumor invasion into the retrohepatic IVC from the right side, and 4) cases with compromised hepatic functional capacity due to chronic liver damages.

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和文抄録

肝右葉切除における短肝静脈，右肝静脈処理 のための前方アプローチ

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巨大肝腫瘍に対する合理的な肝右葉切除法としての前方アプローチを紹介する。

肝右葉切除の標準手技として，右葉の授動と脱転がある。これは肝の右側から，肝部下大静脈に注ぐ短肝静脈や右肝静脈の剝離と切離を行う方法であるが，後区域や右葉全体を占める巨大肝腫瘍の場合には，それらの手技は困難なことが多く，また腫瘍の破裂をきたす恐れもあり危険を伴う。前方アプローチは，右葉の脱転を行わずに直接肝実質を切離して，肝部下大静脈腹側面に到達し，尾状葉突起から頭側に向かって肝実質の離断を進める方法である。肝部下大静脈腹側面に注ぐ短肝静脈を，順次肝離断面側から剝離処理し，最後に右肝静脈の離断も同様に進行。横隔膜浸潤，胸壁，

腹壁浸潤がある場合には，肝切離が終了してから合併切除として最後に行う。また本法は，脱転による残存肝の阻血，門脈血液鬱滞を回避出来る利点があり，肝ミトコンドリアの酸化還元状態を反映する動脈血中ケトン体比（AKBR）の術中低下も軽微であることが判明しており，手術侵襲の点からみても有用である。

前方アプローチの良い適応は，1)後区域，又は右葉全体を占拠するような巨大肝腫瘍の場合，2)腫瘍が右横隔膜，胸壁，腹壁に浸潤している場合，3)右葉の腫瘍の下大静脈への浸潤が疑われ，下大静脈合併切除の可否を判定する場合，4)肝障害のために右葉切除を行うには機能的予備力の点で不安がある場合，などである。